On the organization of the fossil plants of the Coal-measures.[1]

DAVID WHITE.

[The following review contains so much of anatomical importance that we give it this more conspicuous place.—EDS.]

The observations recorded in these three memoirs, while confined chiefly to types, most of which have been treated more or less in the preceding parts, are hardly less remarkable for the information they bring to bear on the mode of the formation of the medulla and the development of exogenous growth in certain Carboniferous cryptogams, than for the proof they furnish of the existence of an exogenous growth among the Carboniferous ferns.

Part XV throws new light on the structure of the rhizomes and petioles belonging to Corda's genera Zygopteris and Anachoropteris, as recognized by Renault, Stenzel, and others, which Williamson shows to be generically equivalent. For these he prefers the name *Rachiopteris* proposed by himself in 1874 (Pt. VI, p. 677) "for a considerable number of these objects which appeared to be either rhizomes or petioles of ferns," for the reason that an examination of the structure of living ferns, classified by their fructification, shows that "no classification of fossil ferns based solely on the characters revealed in transverse sections of their petiolar bundles can be of value." Neither Prof. Williamson nor several other recent authors, seems to be aware of the coincident fact that Dawson in 1861 (Q. J. G. S. L., xviii, p. 323), with equal appropriateness, proposed the new genus *Rhachiopteris* "to include such Devonian stipes as indicate the existence of distinct species of ferns, of which the fronds have perished." Schimper does not seem to have known of Dawson's genus when he established his *Rhacopteris* (Traité, I, 1869, p. 481), based on the character of the fronds. Incognizance of these facts and the too common mis-spelling of the generic names have caused much confusion in the nomenclature.

To a fine species, from the Halifax deposits, related to Renault's *Anachoropteris Decaisnii*, Williamson gives the

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name *Rachiopteris Grayii*, while the section of a hairy branching stem or rhizome, also from Halifax, resembling in many respects the young branches of living Marsileæ, is named *R. hirsuta*. Two roots, from Halifax and Oldham, showing tructure minutely, are called *Rhizonium verticillatum* and *R. reticulatum;* and a third, equally remarkable in structure, whose features resemble those seen in the cortex of *Asterophyllites Williamsonis*, is named *R. lacunosum*. The examination of new specimens of *Calamostachys Binneyana* has enabled the author to fill two gaps in the knowledge of the structure of that interesting form of strobilus, viz. the distribution of the vascular bundles of the central axis, and the peripheral termination of the sporangiophores. Sections of a fertile strobilus through the latter show a thickened distal end, occupied by clusters of tracheids concentrated in the region where each sporangium is organically attached, showing "that these peripheral terminations of the sporangiophores approach even nearer than they were previously known to do to those of the living Equisetum, in corresponding parts of which similar clusters of tracheids exist."

Part XVI is devoted to studies of the mode of branching, the formation of the medulla, and the method of exogenous growth as seen in a number of Lepidodendra, several of which are here first described. The author considers the ordinary mode of branching in this genus to have been dichotomous, with a perfect dichotomy of the medullary vascular cylinder, but that only a segment was cut off from that vascular bundle when the branch was of a special kind, "characterized by an arrested development," such as is represented by the tubercles of *Halonia*, or the scars of *Ulodendron* in which the arrested branches supported Lepidostrobi, both of the latter genera being only "conditions" of various Lepidodendroid genera.

He finds that the germs for the gradual formation of a medulla in the center of a vascular bundle which previously contained no traces of cellular structure were furnished by the procambium from which, in the youngest twigs, the entire bundle originated. The first one or two medullary cells, formed in the centre of the bundle of tracheids, increased by the ordinary meristemic process of enlargement and fission. The internal tension produced by the enlargement of the med-

ullary cellular expansion caused the vessels of the vascular bundle to form a ring increasing in size, the number of vessels also increasing correspondingly and changing their respective positions. This meristemic process is repeated "until the medulla and its surrounding vascular ring attain to their ultimate magnitude—a condition which was probably coincident with the first appearance of the more external exogenous zone." It is probable that the new vessels are produced centrifugally, on the cortical side of the vascular cylinder, though it is possible that some of the young medullary cells assumed a procambial form and were converted into vessels. In any case he considers that the enlargement of the medullary vascular cylinder is mainly, if not wholly, effected "through the internal tension occasioned by the subsequent multiplications and expansions of the medullary cells—a condition that has no existence among the exogenously-grown trees now living." He regards the occurrence of an exogenous growth at some time in the development of all the Carboniferous Lepidodendra as more than probable.

The existence of an exogenous growth among the arborescent Lycopods, Gymnosperms, and Calamarias has long been known. Part XVII of these memoirs has the important office of making known the existence of an exogenous development among the Carboniferous ferns. The anticipation expressed by the author, in Part IV, that *Dictyoxylon* (*Lyginodendron*) *Oldhamium*, there described as belonging to the paleozoic Proto-gymnosperms, might be identical with the petioles described in the same memoir as *Edraxylon*, and later (Part VI) as *Rachiopteris aspera*, is now confirmed, and the two are conclusively proved to be trunk and petiole of the same plant. The study is thorough; the steps in the growth of the petiole from the trunk are observed with the accuracy and minuteness of detail characteristic of the author's former memoirs. The pairs of vascular bundles so characteristic and conspicuous in the middle cortex of *L. Oldhamium* are shown to pass outwards through the outward cortex and become the tracheal bundles of the petioles of *R. aspera*. The clusters of tracheæ, in the small stems, which at first formed one united axial cluster, are separated, the space thus produced at the center being occupied by a steadily expanding parenchymatous medulla. This process is accompanied by a corresponding enormous increase in the number of the vascu-

lar laminæ, the inner extremities of which, though commencing their growth at different periods of life, all start from the medullary border of the vascular zone and extend to the periphery. Among the numerous specimens examined the number of laminæ varied from 44 in a small specimen to 1120 similarly arranged laminæ in a larger one. The transition between the petiolar and trunk structures was not only observed in all stages from many fragments, but specimens were studied in which stem and petiole are organically united, demonstrating not merely that *Lyginodendron Oldhamium* is a true fern, probably belonging to the Sphenopterids, but also that the stems of some, at least, of the Carboniferous ferns "developed their xylem or vascular structure exogenously through the instrumentality of a meristemic zone of the innermost cortex, which practically must be regarded as a cambium layer."

Additional observations on the growth of *Heterangium Grievii* are contributed, without establishing its true affinities, though it seems likely eventually to prove to be a fern. The discovery of the vegetative organs of *Bowmanites (Volkmannia) Dawsoni* and the study of their structure shows an organization generically identical with that of the Asterophyllites described by the author in a former memoir, and the plant described by Renault as *Sphenophyllum Stephanense*. The triangular central vascular axis is the most conspicuous character in the three types. Bowmanites, though it can be regarded as generically identical with the Sphenophylla whose fruits have been definitely correlated, is most strongly allied to the Sphenophylloid type. Williamson calls attention to the fact that evidence is being obtained of the existence of Carboniferous plants whose branches bore both Asterophyllitean and Sphenophylloid leaves (a view supported by Stur's researches among the Schatzlar Calamariæ), and that Sphenophyllum and some forms of Asterophyllites should be united in the same genus. All these types, however, he regards as belonging to the great family Calamariæ, of which Equisetum is "a poor, feeble and degraded member," rather than the central type.

Washington, D. C.